TWO

# DEVELOPMENT

## Arabic *al-Kīmiyā'*

Alchemy developed extensively during its Arabic period, roughly 750 to 1400, augmented in every respect by new theories, concepts, practical techniques, and substances. Centuries of cultivation in the Islamic world produced a massive body of knowledge across the sciences, medicine, and mathematics that would earn the awe and admiration of medieval Europeans when they first encountered it in the twelfth century. Yet although medievals recognized the wealth and importance of Arabic scholarship, that esteem gradually eroded in later generations, until the contributions and even the names of influential Arabic authors became confused, forgotten, or even suppressed. Thus, despite the importance of this period for alchemy—and for the entire history of science—our knowledge of it remains very incomplete. Historians have had to rediscover the primary sources of Arabic alchemy. Only at the end of the nineteenth century did scholars begin to study Arabic alchemical texts again. Strikingly enough, we owe part of this renewal of interest to the chemist Marcellin Berthelot (1827–1907), the same person responsible for the publication of the Greek *Corpus alchemicum*.[1]

Since that time, many questions have been addressed, many gaps in our understanding filled, and many mysteries solved, but much more still awaits attention. Even for the most important Arabic authors, only a few texts have been edited, and fewer translated. Much-needed new scholarship has been stymied by the inherent complexity of the manuscripts and their loss through war and carelessness, as well as by regional political and economic situations that prevent free access to archives. Perhaps the most challenging problem, however, is the very small number of historians of science with linguistic skills in Arabic, and the yet smaller subset of these with an interest in alchemy.

## *The Transmission of Knowledge from Greeks to Arabs*

In the mid-seventh century, shortly after the beginnings of Islam, Arab armies surged out of the Arabian Peninsula in all directions—north into Palestine and Syria, east into Persia, west across North Africa, and finally into Spain and even France. Most important for the story of alchemy is the Arab conquest of the Byzantine lands in the Eastern Mediterranean. In 640, the city of Alexandria was conquered and Egypt annexed to the Islamic Empire. There and in other formerly Byzantine holdings in the Middle East, the nascent Muslim world came into close contact with Greek ideas and culture. This intercultural contact strengthened in 661, when Mu'āwiyah, the second caliph (successors of the prophet Muhammad acting as leaders of Islam) of the Umayyad dynasty, established his capital at Damascus, in the heart of what just thirty years earlier had been Byzantine land. Thus, although the Umayyad caliphs were Muslim Arabs, their subjects were largely Byzantine Christians. The new Muslim rulers were skilled in warfare but not in running an empire, so they needed to employ experienced Byzantines as administrators, architects, and planners. This sociopolitical situation offered ample opportunity for the newly arrived Arabs to learn Greek ideas. Thus, a "translation movement" began, slowly and haltingly under the Umayyads, but greatly accelerated under their successors, the 'Abbasids, who moved the Islamic capital east from Damascus to the new city of Baghdad, which they founded in 762. There a host of translators labored to render hundreds of Greek books into Arabic: the writings of Aristotle and Plato, the mathematics of Euclid, and the medicine of Galen and

Hippocrates, as well as practical treatises dealing with technology, mechanics, and, of course, *chemeia*.[2]

We used to think we knew exactly how Greek *chemeia* first established itself in Arabic culture as *al-kīmiyā'*. The story begins engagingly enough with intrigue and murder at the Umayyad court in Damascus. Khālid ibn-Yazīd (died 704) was a young Umayyad prince, grandson of the caliph Mu'āwiyah. When Khālid's father died in 683 while besieging Mecca during a civil war, Khālid's elder brother succeeded to the caliphate, but died the next year at the age of twenty-two—and possibly not of natural causes. Because of Khālid's youth, the caliphate was then given to a relative by the name of Marwan, with the condition that Khālid would succeed him. But Marwan then married Khālid's widowed mother, promised the line of succession to his own sons, and declared Khālid a bastard. Khālid's mother's response was to smother her new husband with a pillow while he slept (some sources say she poisoned him). Given such a loving family, Khālid fled to Egypt. There, to put his lost caliphate behind him, the young prince began to study Greek learning, and found alchemy most to his liking. In some versions of the story, he encountered "Stephanos the elder," presumably the author Stephanos of Alexandria mentioned in chapter 1. Stephanos taught Khālid and translated alchemical books into Arabic for him. In other versions of the story, Khālid's instruction came instead from a Christian monk named Marianos. Accounts disagree on whether this monk was Greek or Roman, and whether or not he lived as a hermit in Jerusalem. In any event, Marianos had studied alchemy in Alexandria, supposedly under the tutelage of Stephanos, and shared that knowledge—including how to prepare the Philosophers' Stone—with Khālid. The prince himself then wrote several alchemical works to preserve the instructions he had received.

Khālid's books, and his status as "the first [Muslim] for whom medical, astronomical, and chemical writings were translated," are already recorded in a tenth-century Arabic source, as is the Christian monk Marianos.[3] Marianos's books are known today both in Latin translation and in Arabic.[4] Unfortunately, this tidy and engaging tale is pure fiction.[5] The books bearing the names of Marianos and Khālid ibn-Yazīd are actually compositions dating a century or more after the lifetimes of their reputed authors.

Yet there are some consolations for those who like the story. It remains plausible—although there is no clear evidence for it yet—that Egypt was a site for the transmission of the first alchemical texts to the Arabic world, even if Khālid was not involved (the transfer probably began to take place sometime after his death in 704). As for Marianos, Greek knowledge probably did come to Arabic readers at first through the intermediacy of Christian clerics; there are several well-attested examples of such transmission.[6] But the historical existence of Marianos is unlikely. Nevertheless, although this fictional seventh-century monk did not have the distinction of being the first to transmit Greek alchemy to Arabic readers, he would have the honor of being the first bearer of alchemy to another eager readership some five hundred years later. Under the Latinized name Morienus, he will reappear soon.

Without the convenient tale of Khālid and Marianos, the early assimilation of Greek alchemy into the Arabic world during the 700s remains obscure. What little we know of that early period is dominated by treatises written under the names of prominent Greeks. Zosimos's name was used, naturally enough, but so were the names of more famous individuals who never wrote a word about alchemy, such as Socrates, Plato, Aristotle, and Galen. At present we cannot tell if these texts are original Arabic compositions, translations of now-lost pseudonymous Greek works, or some combination of the two.[7]

## *Hermes and the* Emerald Tablet

This early period of pseudoepigraphical Arabic works produced what would become perhaps the most revered and best-known text related to alchemy: the *Emerald Tablet*, attributed to the legendary figure Hermes. Hermes, called Trismegestus from the Greek words meaning "the Thrice-Greatest," is a complex layering of Greek and Egyptian mythological and heroic figures. The writings connected with his name are known collectively as the *Hermetica*, and comprise a diverse jumble of dozens of texts of Greco-Egyptian origin. Many are philosophico-theological of a Neoplatonic character, and date from the first to the fourth century AD. Others are astrological, technical, or magical, and some of these latter date to the first century BC. All these Hermetic texts were well known in late antiquity. None of them, however, bears any clear relation to alchemy.[8]

Yet Zosimos cites a "Hermes" as an authority. More significantly, by the tenth century in the Islamic world, Hermes had grown into the founder of alchemy, a native of Babylon, and the author of a dozen more-or-less alchemical works.[9] His fame and stature continued to grow thereafter. In the Latin West, his renown increased to the point that he was hailed as a contemporary or even a predecessor of Moses and a divinely inspired pagan prophet who foretold the advent of Christ. As a result, Hermes is the first and most prominent prophetic figure depicted in the late fifteenth-century pavement of the Cathedral of Siena in Italy. In Europe, Hermes likewise retained his position as alchemy's founder, to the extent that the term *Hermetic Art* became synonymous with alchemy/chemistry. As a result of the constantly developing myth of Hermes, the *Emerald Tablet*—though merely one paragraph long—developed into a foundational text for many alchemists, both Arabic and Latin. It was subjected to myriad lengthy analyses by dozens of authors, including Isaac Newton.[10]

The exact origin of the *Tablet* remains obscure. Most evidence indicates that it was written centuries after the bulk of the philosophical or technical *Hermetica*, and that it is an original Arabic composition dating from the eighth century. No Greek precursor or any earlier Greek citations of it have been located despite exhaustive searches.[11] It first appeared appended to a work which itself has complex and obscure origins, the *Book of the Secret of Creation* (*Kitāb sirr al-khalīqa*) by one "Balīnūs," an early ninth-century author writing in Arabic under the name of the much earlier Greek author Apollonios of Tyana.[12] Balīnūs's work is itself a pastiche; newer materials are combined with an earlier Syriac text by a priest named Sajiyus of Nablus, which itself incorporates yet older Greek material. How exactly the *Tablet* fits into this muddle remains unclear.[13] Nevertheless, it seems safe enough to doubt the veracity of the account told in the *Book of the Secret of Creation* that the text was discovered, written in Syriac on a tablet of green stone, clenched in the hands of an ancient corpse buried in a subterranean sepulcher hidden beneath a statue of Hermes Trismegestus.[14]

What is clear is that the *Emerald Tablet* never disappeared from view for long thereafter. It reappeared with various wordings and in various textual locations. Trying to make sense of it, however, occupied and frustrated a long line of would-be interpreters. The text is short enough that an early version can be presented here in its entirety.

Truth! Certainty! That in which there is no doubt!

That which is above is from that which is below, and that which is below is from that which is above, working the miracles of one thing.

As all things were from one. Its father is the Sun and its mother the Moon. The Earth carried it in her belly, and the wind nourished it in her belly, as Earth which shall become fire.

Feed the Earth from that which is subtle, with the greatest power.

It ascends from the Earth to the heaven and becomes ruler over that which is above and that which is below.[15]

We can see how readers convinced of the antiquity and importance of this text could have spent many sleepless nights striving to discern its meaning. The relationship between the celestial world (the macrocosm, "that which is above") and the terrestrial world (the microcosm, "that which is below") seems to be clear enough. There also seems to be a reference to monism ("all things were from one"), akin to the meaning of the *ouroboros*. But what is the "it" whose "father is the Sun"? Generations of alchemists believed that "it" was the Philosophers' Stone, the agent of metallic transmutation, and thus that the *Tablet* contained secret information about how to prepare that precious substance. But what are the Sun and Moon? Dry and wet principles perhaps? Gold and silver? Where is the Earth's belly? How and with what subtle thing are we supposed to feed the Earth? It is far from clear that the unspecified "it" has any relation to the stone or to practical alchemy at all. The mysteries of the *Emerald Tablet*—both its origins and its meaning—are not likely to be resolved anytime soon.

There is a curious anecdote dating from the tenth century about early Arabic interest in alchemy. The historian Ibn al-Faqīh al-Hamadhānī describes a visit made by 'Umāra ibn-Hamza, the ambassador from Caliph al-Mansūr, to the Byzantine emperor (probably Constantine V) sometime between 754 and 775.[16] According to this account, the emperor showed 'Umāra several impressive wonders of Constantinople, including storehouses filled with bags of white and red powders. In the sight of the Muslim ambassador, the emperor ordered a pound of lead to be melted, and threw a small amount of the white powder into the crucible. The lead was immediately turned into silver. Then a pound of copper was melted, and upon adding a pinch of the red powder it was transmuted into gold. 'Umāra reported this wondrous feat to al-Mansūr, who then

suddenly developed an interest in alchemy and ordered Greek works about it translated into Arabic. Whether this is a faithful account of what 'Umāra reported or a later rewriting of events, at least the timing is right. For it was in fact under al-Mansūr, the clever founder of Baghdad (reigned 754–75), that the translation movement of scientific and medical works into Arabic began in earnest. This anecdote is of special importance, because it is an early account of *two* transmuting agents, a white one for making silver and a red one for making gold. These two forms of the Philosophers' Stone would become standard parts of transmutational alchemy.

## *Jābir and the Jābirian Corpus*

The obscurity that clouds our understanding of the early transmission of alchemy to the Muslim world does not last long; it is replaced by confusion. For now we come to a person who played as large a role in Arabic alchemy as Zosimos did in the Greco-Egyptian—one Jābir ibn-Ḥayyān. Or, to speak more accurately, several Jābir ibn-Ḥayyāns. Or perhaps none at all. A persistent problem facing historians of alchemy is figuring out if an author really is who he says he is, and if he lived when and where he claims. Anonymity, pseudonymity, secrecy, mysteries, false trails, and subterfuge fill the entire subject from beginning to end. In the case of Jābir, disagreements about both author and his writings began shortly after his reputed lifetime and continue to the present day. As in the case of Khālid and Marianos, things in alchemy are often not what they seem.

Traditional biographies record that Abū Mūsā Jābir ibn-Ḥayyān was born about 720 at Kufa, an ancient town south of Baghdad. In his youth he learned alchemy first from Harbī the Himyarite (who died in 786 at the advanced age of 463) and then from a Christian monk often identified as a disciple of Marianos. (Getting suspicious yet?) Jābir's most important master, however, was a looming figure in Islamic religious history: the sixth Shi'ite Imam, Ja'far al-Ṣādiq (700–765). Jābir attributes his knowledge directly to Ja'far, whose closest and most beloved disciple he claims to have been. Some sources claim that Jābir himself became an imam and/or a Sufi. After Ja'far's death, Jābir went to Baghdad and became close to the rich and powerful Barmaki family, who introduced him to the court of Caliph Hārūn al-Rashīd (of *A Thousand and One Nights*

fame, and who reigned 786–809), for whom Jābir wrote an alchemical volume. Jābir's date of death is variously given as 808, 812, or 815.

Doubts about this account were already circulating in the tenth century. The Baghdadi bookseller Ibn al-Nadīm reports that "many scholars and elders among the booksellers have affirmed that this man, Jābir, did not exist at all."[17] But al-Nadīm rejects this claim on the grounds that no one would write so many books—he lists about three thousand—and put another's name on them. (Authoring three thousand books is not as absurd as it sounds, since these "books" [*kutub*] were akin to chapters or short essays of a few pages, not whole volumes.) Other Arab writers voiced doubts; the fourteenth-century literary historian Jamāl al-Dīn Ibn Nubāta al-Miṣrī asserts that the consensus in his day was that Jābir was a pseudonym used by several different authors.

Arguments about Jābir raged anew in the early twentieth century as historians of science were rediscovering Arabic alchemy. But it was Paul Kraus, a scholar of immense erudition and linguistic prowess, who wrote the decisive work about Jābir.[18] Kraus concluded that the traditional biographies placed Jābir more than a century too early. As evidence, he noted that certain Greek sources to which Jābir refers were not available in Arabic in the eighth century, and that some of Jābir's basic ideas come from that crucial encyclopedic work the *Book of the Secret of Creation*, which was composed between 813 and 833, *after* the dates usually given for Jābir's death. Moreover, the bulk of Jābir's writings show the influence of a Shi'ite movement dating to the end of the 800s.

Kraus also argued that many authors were responsible for Jābir's three thousand books, and that these had been composed over the course of a century. The earliest, *The Book of Mercy* (*Kitāb al-raḥma*), was written in the mid-ninth century. This book, he postulated, excited interest among Shi'ite alchemists, who either wrote companion pieces for it or interpolated their own ideas into other preexisting texts to produce new "Jābir" writings around the end of the ninth century. This group also invented a connection for Jābir to their own historical master, Shi'ite Imam Ja'far al-Ṣādiq (who does not appear in the earlier *Book of Mercy*).[19] Further works were added to Jābir's name until the second half of the tenth century. Thus, the Jābirian corpus represents the evolving production of a "school" of alchemists.[20] There might have been an actual Jābir ibn-Ḥayyān somewhere in all of this, but not one with the biography or bib-

liography claimed for him. Therefore, when I write "Jābir," it is hereafter shorthand for "the authors of the writings under the name Jābir."

### *The Mercury-Sulfur Theory of the Metals*

Jābir's writings contain practical information about processes, materials, and apparatus, along with a wealth of theoretical frameworks. The most enduring contribution connected with him is the *Mercury-Sulfur theory of the metals*. Presented in the *Book of Clarification* (*Kitāb al-īḍāḥ*), this theory has a long history before Jābir. It derives ultimately from Aristotle (384–322 BC), who postulated the existence of two "exhalations" that emanate from the center of the earth; one is dry and smoky, the other wet and steamy.[21] Underground, these exhalations condense and produce stones and minerals. Jābir's immediate source is not Aristotle, however, but rather that crucial early ninth-century work, the *Book of the Secret of Creation* by Balīnūs.[22] Zosimos's interest in sulfur vapor and his notion that mercury is the common "body" of metals may also play an intermediary role between Aristotle and Balīnūs.

The Mercury-Sulfur theory in Balīnūs, as recapitulated in Jābir, states simply that all metals are compounds of two principles called Mercury (akin to Aristotle's moist exhalation) and Sulfur (akin to the smoky exhalation). These two principles, condensed underground, combine in different proportions and degrees of purity to produce the various metals. As Jābir writes,

> The metals are all of the substance of quicksilver coagulated with the mineral sulphur that rises into it in a smoky exhalation of the earth. They differ only in their accidental qualities which depend upon the different forms of sulphur which enter into their composition. For their part, these sulphurs depend upon the different earths and their exposure to the heat of the sun. The most subtle, pure, and balanced sulphur is the sulphur of gold. This sulphur coagulates quicksilver with itself in a complete and balanced manner. On account of this balance, gold withstands fire, remaining unchanged in it.[23]

Thus, gold results from the perfect combination of the finest Sulfur and Mercury in exact proportions. But when the Mercury or Sulfur is

impure, or the two are mixed in the wrong ratio, baser metals are produced. This theory provides the theoretical foundation for transmutation. If all metals share the same two ingredients and differ only in the relative proportions and qualities of those ingredients, then purifying the Mercury and Sulfur in lead and adjusting their ratio should produce gold.

Two points need to be stressed about the Mercury-Sulfur theory of the metals. First, until the eighteenth century, only seven metals were recognized. Two were considered noble (gold and silver), and five were considered base (copper, iron, tin, lead, and mercury).[24] The distinction between "noble" and "base" depended not only upon the relative monetary value of the metals but also upon their intrinsic beauty and their ability to resist corrosion. Second, the metallic principles Mercury and Sulfur were not necessarily identical with the common substances called by those names. These names were attached to the condensed exhalations by analogy with the properties of the common substances. Arabic alchemists knew very well that when they combined common mercury and sulfur in their workshops, they obtained cinnabar (mercuric sulfide), not a metal. The Jābirian corpus even gives a clear recipe for making cinnabar by dripping mercury into molten sulfur.[25]

The Mercury-Sulfur theory proved astonishingly long-lived. It was accepted (in various forms and to various degrees) by most chemical workers until the eighteenth century, almost a thousand years after it was first proposed. This longevity reflects both its conceptual utility and the fact that observable phenomena seem to support it. Some metals, such as iron and copper, burn vividly when finely powdered and dropped into a fire, and in doing so often emit a sulfurous smell. This simple observation supports the idea that they contain some kind of a flammable, sulfur-like substance. Tin and lead melt extremely easily, and when melted are visually indistinguishable from common mercury, thus suggesting that they contain a great deal of some sort of a liquid ingredient similar to mercury. A smaller proportion of this liquid ingredient could explain why iron and copper are so hard to liquefy—they are too "dry." Likewise, tin and lead are soft and pliable, while copper and iron are hard and brittle, as if the former had too much liquid in their composition, and the latter too little (think about, for example, potter's clay mixed with too much or too little water). Finally, the rusting or corrosion of base metals im-

plied that they were "falling apart," decomposing because their ingredients were poorly or weakly combined, unlike the stronger, more stable composition of the noble metals gold and silver.

## *Jābir's Transmuting Elixirs: Aristotelian Qualities, Galenic Degrees, and Pythagorean Numbers*

If transmutation requires just a simple adjustment of proportions, how would this process be carried out in practice? Jābir's practical guidelines start by drawing upon two concepts from Greek natural philosophy. The first is Aristotle's notion of the *four primary qualities* and their relation to the *four elements*. Aristotle stated that the most fundamental (hence "primary") qualities of any thing are hot, cold, wet, and dry. When pairs of these qualities are joined to matter, the four elements—fire, air, water, and earth—result.[26] The combination of hot and dry produces fire, cold-wet gives water, cold-dry produces earth, and hot-wet yields air (see fig. 2.1). Aristotle thought of these four elements as abstract principles of compound bodies, not actual substances that could be put into a jar and labeled. Jābir, however, was more a chemist than Aristotle; in the Jābirian corpus, these elements have concrete existence as isolable, physical substances.

When almost any organic substance—for example, wood, flesh, hair, leaves, eggs—is gradually heated, various materials are driven off sequentially by the heat, leaving behind a solid residue. Jābir interprets this practical experiment as the separation of a compound substance into its component elements. The "fire" distills off as a flammable and/or colored substance, the "air" as an oily one, and the "water" as a watery one; the "earth" remains behind as the residue. Once these elements are separated by distillation, Jābir wants to break them down further by removing one of their two qualities. According to Aristotle, water is the combination of the two qualities wet and cold with matter, so Jābir orders his readers to distill the separated water repeatedly from something with the quality of "dry"—he suggests sulfur. By repeated distillation, the dryness of the sulfur destroys the wetness of the water, so the alchemist is left with something *simpler* than an Aristotelian element: matter endowed with coldness alone. Naturally, the water's manifest properties change as its wetness is removed, and Jābir claims that after repeated treatment the

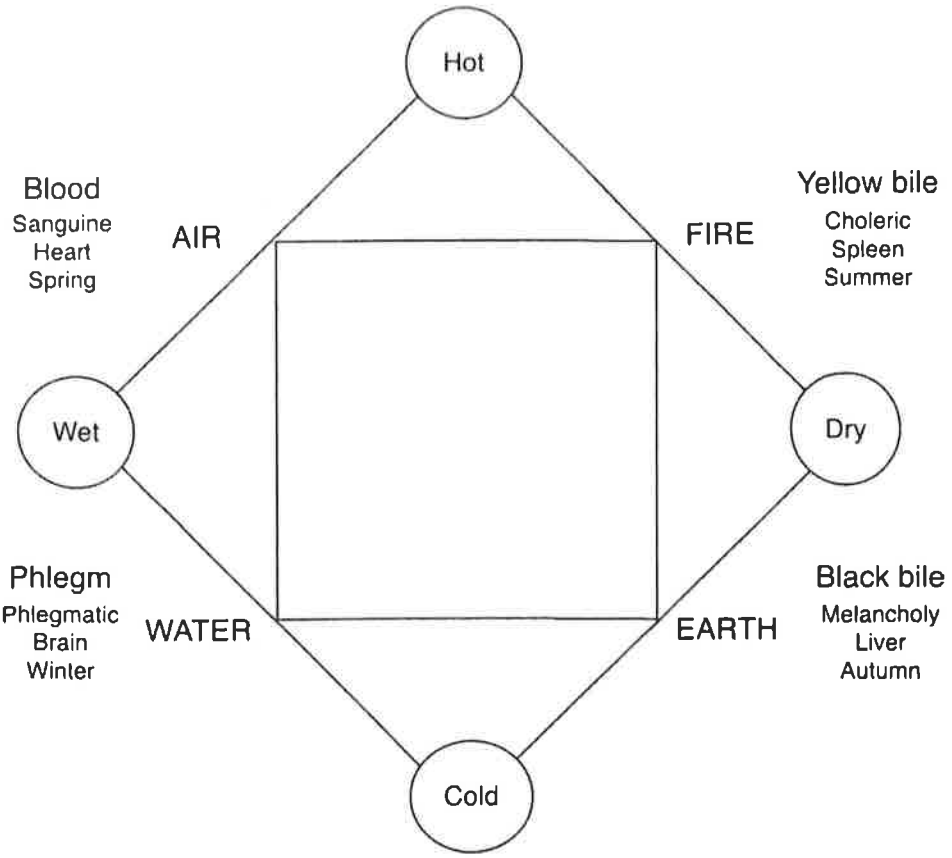


Figure 2.1. A schematic diagram showing the origin of the four elements from the four primary Aristotelian qualities, and the relation of the four humors, complexions, organs, and seasons to the four elements.

water turns into a glistening white solid similar to salt. Each element is to be treated chemically to produce four substances, each one of them bearing just one of the primary Aristotelian qualities.[27]

Once the four single-quality substances are isolated, they can be combined into a transmuting agent. To guide his practice, Jābir now borrows a concept derived ultimately from Greek medicine, but probably transmitted in more developed form through Arabic physicians. The physician Galen of Pergamon (AD 129–99) organized Hippocratic medicine using a system parallel to Aristotle's qualities and elements. In analogy with the four elements fire, air, earth, and water, the human body contains four humors: blood, phlegm, black bile, and yellow bile. These bodily humors were, like the elements, linked to Aristotelian primary qualities: phlegm is cold and wet, black bile is cold and dry, and so forth (fig. 2.1). When the four humors are in proper balance, or "temperament," the body is healthy. But the quantity of each humor varies

depending on diet, activity, location, season, and other factors; when they fall out of balance, illness results. Consequently, the physician must determine the imbalance and supply a treatment that counteracts it.[28] A patient experiencing congested sinuses, runny nose, and depressed activity clearly suffers from an excess of phlegm, an illness that we commonly call—preserving to this day the doctrine of humors and qualities—a "cold," which many (unconsciously Galenic) mothers still believe is caused simply by exposure to cold and wet, rather than by a microorganism. A cure requires either stimulating the body to restore balance on its own, or applying contraries, that is, hot and dry medicines to restore the humoral balance.

Jābir's transmutational system works in just the same way. He teaches that each metal is composed of a precise mathematical ratio of the qualities. Hot and wet predominate in gold, for example, while in lead, cold and dry predominate. Turning lead into gold therefore involves introducing more hot and wet or reducing the cold and dry.[29] Thus, Jābir devises a practical method for getting down to work. After successfully isolating hot and wet, the alchemist can combine them into a substance that when added to lead should adjust its proportion of qualities to the ratio found in gold, thereby transforming it into the precious metal.

Jābir's terminology for his transmuting agents underscores the link to medicine. Greco-Egyptian alchemists had used the word *xērion* to describe the agent of transmutation, a word that originally referred to a type of medicinal powder used for curing wounds. Jābir uses the same medicinal term, but transliterated into Arabic as *al-iksīr*. (To convert *xērion* into Arabic, remove the Greek grammatical ending *-ion*, and add the Arabic definite article *al-* and then an *i* to aid pronunciation.) This Arabic word for the alchemical transmuting agent has come down to us as *elixir*, a term still used for substances, especially medicines, with marvelous effects. Jābir's elixirs "heal" the metals by adjusting their ratio of qualities, just as a medicine heals the sick by adjusting their ratio of humors. Consequently for Jābir, each metal requires a specific elixir, just as each patient requires a specific medicine. Each elixir is composed of mathematically precise amounts of the isolated qualities that, when added to those already present in a particular metal, sum up to the perfect ratio needed for gold. Simple, logical, and elegant!

Jābir's theory of elixirs is novel and original. Because his elixirs are simply combinations of the four qualities in the right proportions, they can

be prepared from virtually anything, because hot, cold, wet, and dry exist in all material substances. This idea stands in stark contrast to the Greek authors who claim that the greatest secret in alchemy is discovering the correct substance from which the transmuting agent is to be made, and who generally stipulate that it is something in the mineral realm. The earliest Jābirian text, the *Book of Mercy*, agrees with the Greek authors, but the later *Seventy Books* prefers to start with animal substances. This change of heart may have stemmed from frustrations in practice: it is easy to decompose animal and vegetable substances by distillation, but difficult or impossible to do so with most mineral substances. Despite the theoretical complexity of the Jābirian texts, and how alien their notions sound in terms of modern chemistry, it is crucial to remember that their authors and readers were actively engaged in practical experimentation. They had extensive experience with a wide range of substances. They watched how these substances reacted to heating and with one another. Accordingly, the Jābirian corpus is full of preparative processes and descriptions of operations and reactions of various kinds.[30]

The Jābirian texts describe three levels of elixirs, distinguished by how well the alchemist has purified the qualities (or "natures," as Jabir calls them) that go into their composition. The purer the qualities, the more powerful the elixir. Lazier alchemists could content themselves with fewer distillations and make elixirs of the first two levels, each of which would work moderately and on only a single metal. The master alchemist, however, would not stop until he had purified the qualities to the utmost degree, because the proper combination of those ultrapure qualities would produce *al-iksīr al-aʿẓam*, the Greatest Elixir, the Philosophers' Stone itself, able to convert any metal into gold.[31]

These ideas all appear in the *Seventy Books*, an early contribution to the Jābirian corpus, dating to the late 800s. As the corpus developed—that is, as other Shi'ite alchemists joined the project and contributed their own ideas and experiences to it—a new level of complexity emerged. Some readers might already be asking the questions that a later Jābirian alchemist must have asked: If we must add to the qualities present in a base metal, don't we first need to know exactly how much of each is present? How do we know how much hot, cold, wet, and dry exist in lead, so that we can know how much more or less is needed to turn it into gold? Today we would think automatically of some empirical method of analysis involving separation and weighing, and so apparently did the earlier

author(s) in the Jābirian corpus. But by the middle of the tenth century, Jābirian authors had begun to think differently about the problem. The starting point continued to be Galenic medical ideas, but the suggested methods for putting them into practice veered off into other—perhaps surprising—areas.

One of Galen's contributions to medicine relates to this very problem of measurement. He introduced a semiquantitative scale to quantify how far off-balance a sick patient's humors were. He subdivided the qualities (hot, cold, wet, dry) into four degrees of intensity, and then classified drugs and illnesses into those degrees. Galen's idea relates to questions of dosage. After all, if a patient was only mildly "cold" (that is, in the first degree), the application of a medicine intensely hot (in the fourth degree) would be dangerous rather than helpful, because it could throw off the balance even further in the opposite direction. The illness and the medicine used to treat it had to be *balanced.*

Jābir's *Books of the Balance* (*Kutub al-Mawāzīn*) apply a modified version of this system to transmutation. Exactly how much more intense is Galen's second degree than the first? Jābir asserts that the relationship between the four degrees is as 1:3:5:8; that is, the second degree is three times more intense than the first, the third five times, and the fourth eight times. Then he subdivides each of these four degrees into seven *grades*, giving a total of twenty-eight levels of intensity for each quality. Next, to ascertain exactly how hot, cold, wet, and dry a particular substance is, he takes a surprising turn, not into quantitative analysis but into Pythagorean number symbolism.

Jābir makes a chart with the four qualities arranged at the top of four columns, and the seven grades of intensity arranged in seven rows, giving a table with twenty-eight boxes. He fills the boxes with the twenty-eight letters of the Arabic alphabet, one in each box, thus assigning a quality and a grade to each letter. Then he takes the name of a substance, say, *usrub* (lead), which in Arabic is written with four letters (*'alif, sin, ra'*, and *ba'*), and analyzes it using the table. The table assigns *'alif* to hot in the highest grade, and since it is the first letter of the word, it is classed as first degree. Thus, we discover that lead is hot in the highest grade of the first degree. The chart assigns the letter *sin* to dry in the fourth grade, and because it is the *second* letter in *usrub*, lead must be dry in the fourth grade of the *second* degree. And so on for the rest of the word. Once this alphabetic analysis is done, another table converts degrees and grades

into actual *weights*, allowing the relative weight of each quality present in lead, or any other substance, to be ascertained. Thereafter one can calculate exactly what weight of each quality needs to be added to a given weight of lead in order to bring its composition to the proportions found in gold.

Modern readers should not feel disappointed by what seems to be an arbitrary system rather than something "scientific" in the modern sense. Instead, it provides the opportunity for reflecting on a crucial point for the history of science. People today and people of the past often do not share the same vision or expectations of the world, nor do they necessarily approach the world in the same way. Their questions were not our questions, nor were their ways of answering them necessarily our ways. What seems arbitrary to one expresses a profound law of nature to the other; what seems an insight into the design of the cosmos to one appears as mere trivia to the other. Recognizing these differences helps us avoid the error of projecting our own knowledge and expectations onto the past as measures of its value.

For Jābir, his alphabetical system is *not* arbitrary; it incorporates eternal verities about the way the world is. Consider first the ratio he gives for the four Galenic degrees of intensity, 1:3:5:8. Where does it come from? The four numbers add up to seventeen. For Jābir, seventeen is the fundamental number for the world—his equivalent, if you will, of what the speed of light or Planck's constant means for us. He did not pick this number out of a hat. This number recurs throughout the ancient Mediterranean world, beginning with the Pythagoreans, a secretive group founded in the sixth century BC, for whom mathematics was key not only to the material world but to philosophy, religion, and life. Their central dictum that "the world is number" proved enormously influential in various ways, even to the present day. Numbers form the basis of what is, and numbers have meaning in themselves, detached from what they acquire by being used to count or measure something. Accordingly, the Pythagoreans sought meaning—both physical and especially metaphysical—in numbers and mathematical relationships.[32] According to Pythagorean principles, seventeen is the sum of two important numbers, seven (which expresses divinity) and ten (which expresses completion). It is also the seventh prime number, the sum of the 9:8 ratio that describes the relationship of adjacent notes in the musical scale, and (nearly) the

length of the hypotenuse of a right isosceles triangle of height twelve. The number makes an indirect appearance even in the gospels. When the resurrected Christ tells the apostles to cast their nets into the sea, they catch 153 fish, which is the "triangular number" of 17, that is, the sum of the first seventeen integers.[33] (It makes me wish the ancients had known about the North American cicadas that make their noisy appearance by the billions once every seventeen years.) Seventeen is also the number of consonants in the Greek alphabet, and in some Neoplatonic systems the vowels represent the immaterial and the consonants the material. With this background in mind, we can see how Jābir viewed seventeen as a fundamental number for all material substances.

Just as numbers held for premoderns a meaning and significance well beyond their use as quantities, so also did words represent much more than conveniences for human communication. It was not arbitrary or naïve for Jābir to analyze the Arabic names of substances in order to learn something about the substances themselves. Muslims believe that the Qur'an was *dictated* to Muhammad—in contrast to orthodox Christians, for whom the holy scriptures were inspired by God but expressed in words chosen by the sacred writers. God's use of Arabic (transmitted by the archangel Gabriel) means that Arabic is a divine language. As such, Arabic words are not arbitrary signifiers of things. They are instead God's names for the things He created, and therefore carry profound meaning and true links to the objects they name. Analyzing the name of a thing can thus reveal something about the thing itself. The same thinking forms the basis of that branch of Jewish Kabbalah known as gematria, and its Christian versions that were explored in the Middle Ages and Renaissance.

Once this difference of worldview is understood, we could even argue that Jābir's underlying aspirations are actually quite similar to our own. His fundamental goal was to classify and quantify natural substances mathematically so that practitioners could work with them in precise, quantitative ways. Seen from this perspective and in context, the system is actually an advanced attempt to standardize and understand mathematically what he saw as the intrinsic qualities of substances. Jābir sought to grasp, unify, and work with the underlying rules and phenomena hidden behind what is visible in the natural world, a fundamental feature of virtually all scientific fields today. Moreover, the successive elaborations

of the "Jābirian" method might well have resulted from failed empirical attempts to get earlier theoretical conceptions to translate successfully into practice.

This final version of Jābirian alchemical theory was not taken up by later alchemists. It was perhaps too complex, and it did not translate out of Arabic. The simpler Mercury-Sulfur theory was, however, widely adopted, and the Latin West learned about it from Jābir, from later Arabic authors who followed him, and even directly from the *Book of the Secret of Creation*. If it seems that the Mercury-Sulfur theory and the four-element theory of composition exist in an uneasy or unclear relationship to each other, this is in part due to the evolution of ideas within the Jābirian corpus. Still, it might be proposed (as some alchemists in fact did) that Mercury is the carrier of cold and wet qualities, while Sulfur carries hot and dry, or that the elements combine to produce Sulfur and Mercury, and these go on in turn to produce the metals.

### *Alchemical Secrecy and Literary Style*

The Jābirian corpus also carries stylistic features that left their mark on subsequent alchemical writers. The first of these is the dispersion of knowledge (*tabdīd al-'ilm*), a method ostensibly for helping to preserve secrecy. Jābir states that "my method is to present knowledge by cutting it up and dispersing it into many places."[34] The idea is that the entirety of Jābir's teaching cannot be found altogether in one place; instead, he distributes a single idea or process piecemeal through one or several books. This technique partly fulfills the charge given to Jābir by his supposed master, Ja'far: "O Jābir, reveal the knowledge as you desire, but such that none have access to it but those who are truly worthy of it."[35] Kraus suggested that the practical reason for this dispersion was to hide the multiple authorship of the Jābirian corpus, allowing later authors to claim that earlier texts were "incomplete," thereby making room for new additions to the corpus, binding its various layers together as a whole, and explaining away contradictions between books.[36] Whatever the original cause, this method would be imitated in many later alchemical texts, and accordingly, Latin alchemists often quoted the motto *Liber librum aperit*, that is, "One book opens another."

The Jābirian corpus shows an increased level of secrecy over earlier texts, but there is little use of *Decknamen* (although these are common

in other Arabic alchemical texts) or the kind of enigmatic allegory deployed by Zosimos.[37] Yet the Jābirian writers are clearly aware of these techniques. Indeed, Jābir exclaims with his characteristic humility, "I have revealed the whole of the science without using enigmas in the least letter; the only enigma consists in the dispersion of knowledge. By God, no one in the world is more generous nor has more mercy on the world and its inhabitants than I!"[38] The reader may be excused for thinking this statement rather disingenuous.

Another stylistic feature that became characteristic of alchemical writing is an "initiatic style."[39] That is, the author writes in a self-consciously grand manner, speaking as the master of a closed circle and addressing his readers as postulants. This initiatic style is evident in portions of the Jābirian corpus where it arises partly from casting the works as teachings of Imam Ja'far, and partly—like the enhanced secrecy—from characteristics of contemporaneous Isma'ili groups. These groups adapted a secretive, initiatic nature from the Neoplatonic philosophies they followed and adopted it as expedient policy, since the more "ultra-Shi'ite" factions were considered religiously unorthodox from the point of view of majority Islam. Yet influences local to the religious and political context in which the Jābirian corpus was written were propagated throughout the rest of alchemy as later writers strove to imitate Jābirian writings. Indeed, Robert Boyle (1627–1691), exasperated at trying to decipher later alchemical texts, would burst out, "These writers, after they have frequently called their reader their son and made solemn professions . . . that they will disclose to him their secrets . . . put him off with riddles instead of instructions."[40]

## *The* Turba *and al-Rāzī's* Secret of Secrets

Around the year 900, another alchemical classic first appeared, known generally by its Latin title *Turba philosophorum* (*The Throng of Philosophers*). The work is cast as a meeting of Greek philosophers. Nine pre-Socratics are named, such as Empedocles, Anaxagoras, Leucippus, and others, and Pythagoras presides over the assembly. Together these characters debate the composition of matter and cosmology, each providing a version of the ideas (sometimes rightly, sometimes wrongly) attributed to their pre-Socratic namesakes. The anonymous Arabic author seems to have drawn upon an early third-century book against heresies

by the church father Hippolytus, and upon the writings of Olympiodorus that compare earlier Greek philosophers with later Greco-Egyptian alchemists, but all this Greek material is translated into an Islamic context. Much of the point of the *Turba* is to demonstrate that the God of Islam is the Creator, that the world is of a uniform nature (monism again), and that all creatures are composed of the four elements.[41] Clearly, this work is of a very different nature from the Jabīrian corpus—it contains no practical instructions and nothing explicitly about chrysopoeia. Nevertheless, many later alchemists esteemed it for its discussion of the nature of matter, a topic obviously of central importance to alchemy. The *Turba* also further indicates the important role of Greek philosophical ideas, and their continued development, within the Islamic world.

Abū Bakr Muhammed ibn-Zakarīyya' al-Rāzī (circa 865–923/4), often known in the Latin world as Rhazes, exemplifies a very different sort of Arabic alchemist. He was born in the city of Rayy in Persia, and became one of most famous physicians and alchemical writers in the Islamic world. His works remained authoritative texts in Europe until the 1600s. It is recorded that al-Rāzī wrote at least twenty-one books about alchemy.[42] He rejected Jābir's theory of balance, but adopted the Mercury-Sulfur theory of the metals, and added to it the notion that sometimes a salt is contained in the metals as well. His best-known work, the *Book of Secrets* (*Kitāb al-asrār*), also called the *Book of the Secret of Secrets* (*Kitāb sirr al-asrār*), was written for one of his students.[43] Often reading almost like a laboratory manual, it begins with a systematic classification of naturally occurring substances—volatile substances ("spirits"), metals, stones, vitriols, borax, and salts—and the different varieties of each. Al-Rāzī carefully describes how to recognize and purify each of them, and continues with descriptions of the apparatus and furnaces needed for various operations. Techniques such as distillation and sublimation are described next. Dozens of recipes then follow for a wide variety of products. The careful detail with which they are given indicates that they are the product of considerable practical experience. The richness of al-Rāzī's inventory of substances and apparatus reveals how substantially Arabic alchemists had expanded the material and technical content of alchemy beyond what earlier Greek writers had known.

Al-Rāzī was also clearly interested in transmutational endeavors—many of the recipes in the *Book of Secrets* yield products supposedly leading to transmutations of one sort or another. Moreover, he added a new

dimension to alchemy's goals, namely, the turning of stones, rock crystal, and even glass into precious stones. These transformations, like those of the metals, were to be carried out by means of specially prepared elixirs. The *Book of Secrets* ends with recipes for a variety of elixirs made from mineral and organic substances such as eggs and hair. Yet much of the content of the book does not relate immediately to transmutation. Alchemy (or, for al-Rāzī, *al-kīmiyā'*) covers much more than just chrysopoeia. The restriction of the word *alchemy* to the context of making gold is a development dating many centuries after al-Rāzī's time. In fact, that narrow definition which now seems so natural did not emerge until the end of the seventeenth century. Before that time, *alchemy* referred to all the processes and concepts we might today consider broadly "chemical." In other words, al-Rāzī's classification system of substances is most certainly a central part of the history of alchemy, even when it does not relate to transmutation.

### *Ibn-Sīnā and the Critics of Transmutation*

As alchemy expanded and developed during the Arabic period, so did reactions against it in the form of criticism, skepticism, and the denial of alchemical claims. If such anti-alchemical literature existed in the Greco-Egyptian period, it no longer survives.[44] But in the Arabic world, dissent became common. Al-Kindī (died 870), a prolific writer deeply interested in Greek philosophy and scientific thought, wrote a short treatise against the reality of chrysopoeia, although it is now lost.[45] Al-Rāzī, on the other hand, came to transmutation's defense and wrote his own tract—also now lost—refuting al-Kindī.[46]

The most influential attack on chrysopoeia came from the pen of ibn-Sīnā (circa 980–1037), generally known as Avicenna in the Latin world. Like al-Rāzī, ibn-Sīnā was a Persian, and wrote medical texts, most notably his authoritative treatise *The Canon* (*al-Qānūn*), which became a fundamental authority for European medical schools until the seventeenth century. Yet he also addressed the topic of alchemy. One of ibn-Sīnā's works, the *Treatise on the Elixir* (*Risālat al-iksīr*), claims wide familiarity with texts both for and against alchemy (he was impressed by neither), and is cautiously positive about chrysopoeia. Yet the attribution of the *Treatise* remains a topic of debate; if it really is ibn-Sīnā's, it may express early ideas.[47] What is clearer is that his better-known *Book*

*of the Remedy* (*Kitāb al-shifā'*) comes to a different conclusion. This unquestionably authentic work contains a section about minerals where ibn-Sīnā discusses the formation of minerals and metals, adopting the Mercury-Sulfur theory that by his time had become standard. But unlike al-Rāzī and other alchemical writers, ibn-Sīnā then goes on to deny the possibility of metallic transmutation: "As to the claims of the alchemists, it must be clearly understood that it is not in their power to bring about any true change of species."[48] The core of ibn-Sīnā's rejection involves two closely related points: human weakness and human ignorance. For the first, he states that the power of human industry is simply weaker than nature: "Alchemy falls short of nature . . . and cannot overtake her."[49] Or, as he states in another book, "Whatever God created through natural powers cannot be imitated artificially; human industry is not the same as what nature does."[50]

Ibn-Sīnā believes that artificially prepared things can never be identical to natural ones, whether we are talking about gold, gems, or anything else. Thus, he would agree with those people today who (incorrectly) believe that the vitamin C in an orange is somehow different from that which is produced chemically for vitamin supplements. Regarding human ignorance, ibn-Sīnā claims that what we sense and identify as the differences between metals—that is, what alchemists endeavor to alter—are not their true, essential differences, merely superficial ones. The true differences are unknown to us, hidden within the very essences of things. If we do not know what those true differences are, we cannot produce or change them correctly. Therefore, given this combination of weakness and ignorance, alchemists attempting to transmute metals "can make excellent imitations . . . yet in these [imitations] the essential nature remains unchanged; they are merely so dominated by induced qualities that errors may be made concerning them."[51] In other words, alchemical gold might very well look like gold, have all the apparent characteristics of gold, and convince at least some people that it is indeed gold, but it is not really *true* gold.

Ibn-Sīnā's denial of the possibility of true transmutation turned out to be extremely influential, for this section of his *Book of the Remedy* would later be translated into Latin and widely circulated in Europe, often under the weighty name of Aristotle himself (see chapter 3). But while ibn-Sīnā's critique provided ammunition for those who sought to discredit alchemy, it did little to dampen the interest of those who pursued

it. Several later Islamic alchemists wrote refutations of ibn-Sīnā—most notably al-Ṭughrā'ī in the early twelfth century.[52] There are two important points to stress. First, after their emergence in the Arabic world, critical views of alchemy never vanished; alchemy would remain forever after a controversial subject, with parties vigorously arguing for or against it down through the centuries. Second, while ibn-Sīnā's critique is based on philosophical principles—influenced in part by Aristotelian thinking—his concession that alchemists can make something that looks so much like gold that it can fool people leads naturally to another sort of criticism: the connection of transmutation to intentional fraud.

Tales of the charlatan alchemist are not uncommon in the Arabic world, though the earlier Greek world shows almost no sign of such stories.[53] Al-Kindī's lost anti-chrysopoetic treatise reportedly cataloged tricks used by such charlatans to deceive the unwary. But 'Abd al-Raḥmān al-Jawbarī provides a longer inventory of shady alchemical dealings. Around the year 1220, al-Jawbari wrote a book called *The Revelation of Secrets* that details a variety of cheats and swindles. He recounts the sleights of hand used by false alchemists to dupe the unwary—gold hidden inside charcoals, under the false bottom of a crucible, or within metal implements that is made to appear at the right moment as if produced by transmutation. Curiously, alchemists would be accused of many of the very same tricks into the eighteenth century. Among his many anecdotes, al-Jawbari includes one about a man who asks a goldsmith to sell ingots of silver for him, and then befriends the goldsmith with his generosity. When the man's evident wealth disappears, the goldsmith asks the cause, and learns his new friend is an alchemist who has run out of the transmuting elixir, and now—through various misfortunes—has neither place nor resources to produce more. The goldsmith (of course) invites him into his house and provides him with the necessary equipment and materials, including a substantial amount of gold and silver. The alchemist sets to work making a fresh batch of elixir with the promise to share it. Needing a particular mineral to complete his work, the alchemist sends the goldsmith off to collect it. When the goldsmith returns home, the "alchemist" is gone, along with the gold and silver.[54]

Al-Jawbari's purpose was to entertain the reader with amusing tales of the cleverness of con men and the gullibility of their victims. The proportion of fact to fiction in these anecdotes is impossible to assess, and so it remains unclear whether such traveling impostors really

existed or if these accounts were simply humorous and plausible fictions. Nevertheless, such stories provide a tantalizing look at one role the figure of the alchemist played in Islamic popular culture. Unfortunately, we have precious few surviving sources—or at least few that are currently known and available—that can tell us much more about this important point in the history of alchemy. We will have to wait until we reach early modern Europe—where sources are more plentiful—to explore that particular topic.

Another insight into the actual lives of alchemists in the Islamic world occurs much later, in a sixteenth-century work by Leo Africanus, a freed slave and Christian convert sent by Pope Leo X to compile a descriptive account of Northern Africa. Leo gives a highly unflattering account of the many alchemists who inhabited the Moroccan city of Fez. They stink of sulfur, and assemble nightly at the chief mosque to debate their processes. Some among them seek the elixir using the works of Jābir, while others seek ways to extend precious metals. "But their chiefest drift is to coin counterfeit money, for which cause you shall see most of them in Fez with their hands cut off."[55] (Leo does not explain exactly how they could persist in practicing alchemy without hands.) Charges of forgery and counterfeiting would continue to vex alchemists in both Muslim and Christian worlds.

Alchemy continued to flourish in the Arabic world long after al-Rāzī and ibn-Sīnā.[56] The historian of alchemy E. J. Holmyard was taken to see a working subterranean alchemical laboratory outside Fez in the 1950s.[57] (Such places continue to exist in Europe and North America as well.) Moreover, I have heard anecdotally from colleagues of their meeting Muslim alchemists still at work on transmutation even today in Egypt and Iran. But having now sampled the theoretical and material sophistication that alchemy acquired in the Islamic world, it is time to move on to alchemy's third cultural context. By the twelfth century, the Dār al-Islām, or Abode of Islam, shared borders with another civilization in three places—Palestine, Sicily, and Spain—and that other culture, Western Christianity, had begun a process of vigorous growth and renewal. Latin Europe was ready to discover, within the vast intellectual wealth of Islam, the golden promises of *al-kīmiyā'*.

33. Robert Halleux, *Les textes alchimiques* (Turnhout, Belgium: Brepols, 1979), pp. 45–47.

34. For an overview see Michèle Mertens, "Graeco-Egyptian Alchemy in Byzantium," in *The Occult Sciences in Byzantium*, ed. Paul Magdalino and Maria Mavroudi (Geneva: La Pomme d'Or, 2006), pp. 205–30.

35. Cristina Viano, "Les alchimistes gréco-alexandrins et le *Timée* de Platon," in *L'Alchimie et ses racines philosophiques: La tradition grecque et la tradition arabe*, ed. Cristina Viano (Paris: Vrin, 2005), pp. 91–108; "Aristote et l'alchimie grecque," *Revue d'histoire des sciences* 49 (1996): 189–213; *La matière des choses: Le livre IV des Météorologiques d'Aristote et son interprétation par Olympiodore* (Paris: Vrin, 2006), esp. appendix 1, pp. 199–208: "Olympiodore l'alchimiste"; "Olympiodore l'alchimiste et les Présocratiques," in *Alchemie: Art, histoire, et mythes*, ed. Didier Kahn and Sylvain Matton (Paris: SÉHA, 1995), pp. 95–150; and "Le commentaire d'Olympiodore au livre IV des *Météorologiques* d'Aristote," in *Aristoteles chemicus*, ed. Cristina Viano (Sankt Augustin, Germany: Academia Verlag, 2002), pp. 59–79.

36. There has been a long debate whether the Stephanos of the *Corpus alchemicum graecum* is the same person as the Neoplatonic philosopher Stephanos. The most recent evidence leads to the conclusion that he is. See Maria K. Papathanassiou, "L'Oeuvre alchimique de Stephanos d'Alexandrie," in Viano, *L'Alchimie et ses racines*, pp. 113–33; "Stephanus of Alexandria: On the Structure and Date of His Alchemical Work," *Medicina nei secoli* 8 (1996): 247–66; and "Stephanos of Alexandria: A Famous Byzantine Scholar, Alchemist and Astrologer," in Madgalino and Mavroudi, *Occult Sciences*, pp. 163–203. A rough English translation is available in Frank Sherwood Taylor, "Alchemical Works of Stephanus of Alexandria, Part I," *Ambix* 1 (1937): 116–39, and "Part II," *Ambix* 2 (1938): 39–49.

37. The phrase "stone that is no stone" appears in Zosimos (Mertens, *Les alchimistes grecs IV, i: Zosime*, p. 49). Note that the correct term is *Philosophers' Stone*, not the commonly encountered *Philosopher's Stone*. All original sources in various languages use the plural possessive: *Stone of the Philosophers*.

## *Chapter Two*

1. Marcellin Berthelot, Rubens Duval, and O. Houdas, *La chimie au moyen âge*, 3 vols. (Paris, 1893).

2. For a good treatment of the translation movement, see Dimitri Gutas, *Greek Thought, Arabic Culture: The Graeco-Arabic Translation Movement in Baghdad and Early 'Abbasid Society* (London: Routledge, 1998). For a quicker introduction, see David C. Lindberg, *The Beginnings of Western Science*, 2nd ed. (Chicago: University of Chicago Press, 2007), pp. 166–76.

3. This information comes from the *Catalogue* (*al-Fihrist*) composed in 987 by the Baghdad bookseller Ibn al-Nadīm, one of the greatest resources for bibliographers of Arabic sources. An English translation of the section covering alchemy is J. W. Fück, "The Arabic Literature on Alchemy according to An-Nadīm," *Ambix* 4 (1951): 81–144; this section contains an early version of the story of Khālid and his books on p. 89 and in the notes on p. 120.

4. Morienus, *De compositione alchemiae*, in *Bibliotheca chemica curiosa*, ed. J. J. Manget (Geneva, 1702; reprint, Sala Bolognese: Arnoldo Forni, 1976), 1:509–19; Ullmann, *Natur- und Geheimwissenschaften*, pp. 191–95; Ahmad Y. al-Hassan, "The

Arabic Original of the *Liber de compositione alchemiae*," *Arabic Sciences and Philosophy* 14 (2004): 213–31.

5. Julius Ruska, *Arabische Alchemisten I: Châlid ibn-Jazîd ibn-Mu āwija, Heidelberger Akten von-Portheim-Stiftung* 6 (1924; reprint, Vaduz, Liechtenstein: Sändig Reprint Verlag, 1977); Manfred Ullmann, "Hālid ibn-Yazīd und die Alchemie: Eine Legende," *Der Islam* 55 (1978): 181–218.

6. For example, Patriarch Timothy I prepared the first Arabic version of a work by Aristotle (the *Topics*) for the caliph al-Mahdī around 782; Gutas, *Greek Thought*, pp. 61–69.

7. For short descriptions of these early productions, see Georges C. Anawati, "L'alchimie arabe," in *Histoire des sciences arabes*, ed. Roshdi Rashed and Régis Morelon, vol. 3, *Technologie, alchimie et sciences de la vie* (Paris: Seuil, 1997), pp. 111–42, and Ullmann, *Natur- und Geheimwissenschaften*, pp. 151–91.

8. On Hermes and Hermeticism, see Hanegraaff, Faivre, van den Broek, and Brach, *Dictionary of Gnosis and Western Esotericism*, 1:474–570; Garth Fowden, *The Egyptian Hermes: A Historical Approach to the Late Pagan Mind* (Cambridge: Cambridge University Press, 1986) [useful for Hermes, but the material on Zosimos and alchemy is now outdated]; and Florian Ebeling, *The Secret History of Hermes Trismegestus: Hermeticism from Ancient to Modern Times* (Ithaca, NY: Cornell University Press, 2007), pp. 3–36; for the philosophico-theological texts see Brian Copenhaver, *Hermetica: The Greek Corpus Hermeticum and the Latin Asclepius* (Cambridge: Cambridge University Press, 1992).

9. For the Arabic Hermes and texts attributed to him, see Ullmann, *Natur- und Geheimwissenschaften*, pp. 165–72 and 368–78; Fück, "An-Nadim," pp. 89–91; and Martin Plessner, "Hermes Trismegistus and Arab Science," *Studia Islamica* 2 (1954): 45–59. On the growth of the Arabic myth of Hermes (with little about alchemy), see Kevin T. Van Bladel, *The Arabic Hermes: From Pagan Sage to Prophet of Science* (Oxford: Oxford University Press, 2009).

10. For one version of Hermes Trismegestus as the ancient father of alchemy, see Michael Maier, *Symbola aureae mensae duodecim nationum* (Frankfurt, 1617), pp. 5–19; for the usage of the term *Hermetic Art*, see Bernard Joly, "La rationalité de l'Hermétisme: La figure d'Hermès dans l'alchimie à l'âge classique," *Methodos* 3 (2003): 61–82, and Jean Beguin, *Tyrocinium chymicum* (Paris, 1612), pp. 1–2: "If anyone should call it [chymistry] the Hermetic Art, he refers to its originator and antiquity." For the seventeenth-century attack on Hermes' date and prophetic status, see Anthony Grafton, "Protestant versus Prophet: Isaac Casaubon on Hermes Trismegistus," *Journal of the Warburg and Courtauld Institutes* 46 (1983): 78–93. For a lengthy early modern alchemical commentary, see Gerhard Dorn, *Physica Trismegesti*, in *Theatrum chemicum*, 1:362–87; and on Newton, J. E. McGuire and P. M. Rattansi, "Newton and the Pipes of Pan," *Notes and Records of the Royal Society of London* 21 (1966): 108–43, and B. J. T. Dobbs, "Newton's Commentary on *The Emerald Tablet* of Hermes Trismegestus: Its Scientific and Theological Significance," in *Hermeticism and the Renaissance*, ed. Ingrid Merkel and Allen G. Debus (Washington, DC: Folger Shakespeare Library, 1988), pp. 182–91.

11. Julius Ruska, *Tabula Smaragdina: Ein Beitrag zur Geschichte der hermetischen Literatur* (Heidelberg: Winter, 1926); Martin Plessner, "Neue Materialien zur Geschichte der Tabula Smaragdina," *Der Islam* 16 (1928): 77–113; for a summary of the

history of the *Tablet* and several versions of its text, see Didier Kahn, ed., *La table d'émeraude et sa tradition alchimique* (Paris: Belles Lettres, 1994).

12. Balīnūs is actually the Arabic rendering of Apollonios. Arabic has no *p*, so that letter becomes *b*, giving "Abollonios," which, with the vowel modifications typical of translating into and out of Arabic (the language has only three vowels—*a*, *i*, and *u*—and does not indicate short vowels in writing), gives "Balīnūs."

13. The Arabic text of the *Kitāb sirr al-khalīqa* was not edited and published until 1979: Ursula Weisser, ed., *Sirr al-khalīqah wa ṣan'āt al-ṭabī'ah* (Aleppo: Aleppo Institute for the History of Arabic Science, 1979). A summary of its contents is currently available in Ursula Weisser, *Das "Buch über das Geheimnis der Schöpfung" von Pseudo-Apollonios von Tyana* (Berlin: Walter de Gruyter, 1980; reprint, 2010), and an edition of the medieval Latin translation edited by Françoise Hudry is "Le *De secretis naturae* du pseudo-Apollonius de Tyane: Traduction latine par Hugues de Santalla du *Kitāb sirr al-ḫalīqa* de Balīnūs," in "Cinq traités alchimique médiévaux," *Chrysopoeia* 6 (1997–99): 1–153.

14. The discovery of arcane texts in underground burial chambers or in ancient Egyptian monuments had become a literary device by the Islamic period; see Ruska, *Tabula*, pp. 61–68.

15. English translation from the Arabic provided by E. J. Holmyard, "The Emerald Table," *Nature* 112 (1923): 525–26, quoting from p. 526. Note, however, that Holmyard's historical claims in this article about the origin and dating of the *Tabula* have since been shown to be wrong.

16. Gotthard Strohmaier, "'Umāra ibn Hamza, Constantine V, and the Invention of the Elixir," *Graeco-Arabica* 4 (1991): 21–24; a fuller account is Strohmaier, "Al-Mansūr und die frühe Rezeption der griechischen Alchemie," *Zeitschrift für Geschichte der Arabisch-Islamischen Wissenschaften* 5 (1989): 167–77.

17. Fück, "An-Nadim," p. 96.

18. Paul Kraus, *Jābir ibn Ḥayyān: Contribution à l'histoire des idées scientifiques dans l'Islam*, vol. 1, *Le Corpus des écrits jābiriens*, *Mémoires de l'Institut d'Égypte* 44 (1943), and vol. 2, *Jābir et la science grecque*, *Mémoires de l'Institut d'Égypte* 45 (1942). The second volume has been reprinted by Les Belles Lettres (Paris, 1986). In 1944, as Kraus was completing a third book that situated Jābir in the context of Islamic religious history, he was found hanged in his apartment in Cairo. Doubts remain whether it was suicide or murder. To make matters worse, much of the manuscript of his third book was lost after his death. This unequaled scholar who solved so many difficult mysteries of the past departed tragically in a mystery of his own; and while he painstakingly recovered books that had been lost for centuries, most of his own final book perished due to carelessness.

19. An alchemical text bearing the name of Ja'far has been found, but it has been shown to be a later forgery. See Julius Ruska, *Arabische Alchemisten II: Ğa'far alṣādiq, der Sechste Imām*, *Heidelberger Akten von-Portheim-Stiftung* 10 (1924; reprint, Vaduz, Liechtenstein: Sändig Reprint Verlag, 1977). This publication includes a German translation of the alchemical text attributed to Ja'far.

20. This view is summarized in Kraus, *Le Corpus des écrits jābiriens*, pp. xlv–lxv.

21. Aristotle, *Meteorologica* 3.6.378a17–b6.

22. Kraus, *Jābir et la science grecque*, pp. 270–303, and Pinella Travaglia, "I *Meteorologica* nella tradizione eremetica araba: il *Kitāb sirr al-ḫaliqa*," in Viano, *Aristoteles chemicus*, pp. 99–112.

23. Jābir, *Kitāb al-īḍāḥ*, in *The Arabic Works of Jābir ibn Ḥayyān*, ed. and trans. E. J. Holmyard (Paris: Geuthner, 1928), p. 54 [Arabic text]; E. J. Holmyard, "Jābir ibn-Ḥayyān," *Proceedings of the Royal Society of Medicine, Section of the History of Medicine* 16 (1923): 46–57, quoting from p. 56 [partial English translation]; Karl Garbers and Jost Weyer, eds., *Quellengeschichtliches Lesebuch zur Chemie und Alchemie der Araber im Mittelalter* (Hamburg: Helmut Buske Verlag, 1980), pp. 34–35 [German and Arabic].

24. Greek alchemists did not classify mercury as one of the metals; some texts in the Jābirian corpus do and others do not. It was generally considered a metal in later Arabic alchemy and in Latin alchemy.

25. Garbers and Weyer, *Lesebuch*, pp. 14–15; Holmyard, "Jābir," p. 57.

26. See Lindberg, *Beginnings of Western Science*, pp. 31, 53–54.

27. These processes are described in detail in Kraus, *Jābir et la science grecque*, pp. 4–18.

28. For a quick overview of Galenic medicine, see G. E. R. Lloyd, *Greek Science after Aristotle* (New York: Norton, 1973), pp. 136–53, esp. 138–40; for the development of the system of degrees by al-Kindī, see Pinella Travaglia, *Magic, Causality and Intentionality: The Doctrine of Rays in al-Kindī*, Micrologus Library 3 (Florence: Sismel, 1999), pp. 73–96.

29. Indeed, Jābir says that the opposite qualities already exist at the "interior" of substances, and so need to be exchanged with the contrary exterior properties. See Kraus, *Jābir et la science grecque*, pp. 1–3.

30. Very little of the Jābirian corpus has been published. A selection of edited Arabic texts exists in Holmyard, *The Arabic Works of Jābir ibn-Ḥayyān*; Paul Kraus, *Jābir ibn-Ḥayyān: Textes choisis* (Paris: Maisonneuve, 1935); and Pierre Lory, *L'Élaboration de l'Élixir Suprême* (Damascus: Institut Français de Damas, 1988) [the first fourteen treatises from the *Seventy Books*]. Translations into European languages (none into English) are Alfred Siggel, ed., *Das Buch der Gifte des Ǧābir ibn-Ḥayyān* (Wiesbaden: Akademie der Wissenschaften und der Literatur, 1958) [Arabic of *Kitāb al-sumūm*, with German translation], and Pierre Lory, trans., *Dix traités d'alchimie* (Paris: Sinbad, 1983) [first ten treatises of the *Seventy Books* into French]. The earliest text, the *Kitāb al-raḥma*, also exists in a medieval Latin translation, first edited by Ernst Darmstaedter, "Liber Misericordiae Geber: Eine lateinische Übersetzung des grösseren Kitāb alrahma," *Archiv für Geschichte der Medizin* 17 (1925): 187–97, and a medieval Latin translation of the *Seventy Books* is published by Marcellin Berthelot, *Mémoires de l'Académie des Sciences* 49 (1906): 308–77. Lory (*Dix traités*, pp. 79–89) has a good account of Jābir's apparatus and operations, and Kraus (*Jābir et la science grecque*, pp. 3–18) lays out the steps in the preparation of the elixirs very clearly, with extended practical passages rendered into French, pp. 3–18.

31. Kraus, *Jābir et la science grecque*, pp. 6–7; Lory, *Dix traités*, pp. 91–94.

32. For an entrée into Pythagoreanism, see Carl Huffman's article in Jacques Brunschwig and Geoffrey E. R. Lloyd, eds., *Greek Thought: A Guide to Classical Knowledge* (Cambridge, MA: Belknap Press of Harvard University Press, 2000), pp. 918–36; for a valuable overview of number symbolism, see Jean-Pierre Brach's article "Number Symbolism" in Hanegraaff, Faivre, van den Broek, and Brach, *Dictionary of Gnosis and Western Esotericism*, 2:874–83.

33. John 21:3–14. The early church fathers, formed in the intellectual culture of late antiquity, had no problem "reading" this number of fish as one of completion and universality, the catch of 153 fish meaning every race and nation on earth would be

saved within the church, the net that did not break despite the strain; see for example St. Augustine, *On the Gospel of John*, tractate 122. To understand a "triangular number," draw a single dot, then two dots in a row beneath it to mark the corners of an equilateral triangle. Expand the triangle with a row of three dots beneath the row of two, and continue with rows of four, five, six, and so forth. When you reach seventeen rows, the total number of dots will be 153, the "triangular number" of 17.

34. Jābir, quoted in Kraus, *Le corpus des écrits jābiriens*, p. xxvii.

35. Ibid.

36. Ibid., pp. xxxiii–xxxiv.

37. Julius Ruska and E. Wiedemann catalog some Arabic *Decknamen* found in a work of al-Tughrā'ī (eleventh century) in "Beiträge zur Geschichte der Naturwissenschaften I.XVII: Alchemistische Decknamen," *Sitzungsberichte der Physikalisch-medizinalischen Societät zu Erlangen* 56 (1924):17–36; a longer list drawn from more sources is given by Alfred Siggel, *Decknamen in der arabischen alchemistischen Literatur* (Berlin: Akademie Verlag, 1951).

38. Quoted from the *Book of Properties* (*Kitāb al-khawāss*) in Kraus, *Le corpus des écrits jābiriens*, p. xxviii.

39. William R. Newman, *The Summa Perfectionis of the Pseudo-Geber: A Critical Edition, Translation, and Study* (Leiden: Brill, 1991), p. 90.

40. Robert Boyle, *Dialogue on Transmutation*, edited in Lawrence M. Principe, *The Aspiring Adept: Robert Boyle and His Alchemical Quest* (Princeton, NJ: Princeton University Press, 1998), pp. 233–95, quoting from pp. 273–74; text modernized here.

41. Martin Plessner, "The Place of the *Turba Philosophorum* in the Development of Alchemy," *Isis* 45 (1954): 331–38, and *Vorsokratische Philosophie und griechische Alchemie* (Wiesbaden: Steiner, 1975). Plessner's work extends and corrects the foundational, and still valuable, work on the text by Julius Ruska, *Turba philosophorum: Ein Beitrag zur Geschichte der Alchemie* (Berlin: Springer, 1931).

42. Julius Ruska, "Al-Biruni als Quelle für das Leben und die Schriften al-Rāzī's," *Isis* 5 (1923): 26–50; "Die Alchemie ar-Razi's," *Der Islam* 22 (1935): 281–319.

43. Julius Ruska, *Al-Rāzī's Buch der Geheimnis der Geheimnisse* (Berlin: Springer, 1937; reprint, Graz: Verlag Geheimes Wissen, 2007) [contains a complete German translation of Al-Rāzī's text]; H. E. Stapleton, R. F. Azo, and M. Hidayat Husain, "Chemistry in Iraq and Persia in the Tenth Century AD," *Memoirs of the Asiatic Society of Bengal* 8 (1927): 317–418 [contains a partial English translation of Al-Rāzī's text].

44. There is a brief comment by the fifth-century Neoplatonic philosopher Proclus that seems to deny that alchemists can make gold in the same way that nature does, although it is not clear that he denies chrysopoeia itself; Proclus, *Commentary on the Republic*, 2.234.17.

45. On al-Kindī, see Felix Klein-Francke, "Al-Kindi," in *The History of Islamic Philosophy*, ed. Seyyed Hossein Nasr and Oliver Leaman (New York: Routledge, 1996), pp. 165–77. Reference to his lost work against chrysopoeia is made by al-Mas'ūdī (died 956) in his *Murūj al-dhahab*, available in French translation: *Les Prairies d'Or*, trans. B. de Maynard and P. de Courteille (Paris, 1861–1917), 5:159.

46. The work is listed in medieval catalogs (both Arabic and Latin) of al-Razi's works, see G. S. A. Ranking, "The Life and Works of Rhazes (Abu Bakr Muhammad bin Zakariya ar-Razi)," *XVII International Congress of Medicine, London 1913, Proceedings*, section 23, pp. 237–68; on p. 249, no. 40.

47. Julius Ruska, "Die Alchemie des Avicenna," *Isis* 21 (1934): 14–51, judged the work to be a Latin forgery, but an Arabic text exists; see H. E. Stapleton, R. F. Azo, Hidayat Husain, and G. L. Lewis, "Two Alchemical Treatises Attributed to Avicenna," *Ambix* 10 (1962): 41–82. The Arabic text, a French translation, and the medieval Latin version are all provided in Georges C. Anawati, "Avicenna et l'alchimie," in *Convegno internazionale, 9–15 aprile 1969: Oriente e occidente nel medioevo: filosofia e scienze* (Rome: Accademia Nazionale dei Lincei, 1971), pp. 285–345.

48. E. J. Holmyard and D. C. Mandeville, eds., *Avicennae de congelatione et conglutinatione lapidum, Being Sections of the Kitāb al-Shifā'* (Paris: Paul Geuthner, 1927), p. 40. This edition contains Latin and Arabic texts with an English translation of the latter, plus notes.

49. Ibid., p. 41.

50. Ibn-Sīnā, quoted in A. F. Mehrens, "Vues d'Avicenne sur astrologie et sur le rapport de la responsabilité humaine avec le destin," *Muséon* 3 (1884): 383–403, quoting from p. 387.

51. Ibn-Sīnā, quoted in Holmyard and Mandeville, *Avicennae de Congelatione*, p. 41.

52. For a summary, see Ullmann, *Natur- und Geheimwissenschaften*, pp. 249–55.

53. One exception is an account of John Isthmeos, who appeared in Antioch in 504, swindling many people there before moving to Constantinople, where he continued his trade until he was exiled; see Mertens, "Graeco Egyptian Alchemy," pp. 226–27.

54. The text exists in French translation as al-Jawbari, *La voile arraché*, trans. René R. Khawan, 2 vols. (Paris: Phèbus, 1979); the section on chrysopoeia is 1:183–229. A partial English translation appears in Harold J. Abrahams, "Al-Jawbari on False Alchemists," *Ambix* 31 (1984): 84–87.

55. Leo Africanus, *A Geographicall Historie of Africa* (London, 1600), pp. 155–56. The text was originally published in 1526 in Italian. On Fez as a continuing center of alchemy, see José Rodríguez Guerrero, "Some Forgotten Fez Alchemists and the Loss of the Peñon de Vélez de la Gomera in the Sixteenth Century," in *Chymia: Science and Nature in Medieval and Early Modern Europe*, ed. Miguel López-Pérez, Didier Kahn, and Mar Rey Bueno (Newcastle-upon-Tyne: Cambridge Scholars Publishing, 2010), pp. 291–309.

56. For a summary of some of these later alchemical authors, see Ullmann, *Natur- und Geheimwissenschaften*, pp. 224–48.

57. Holmyard, *Alchemy*, p. 104.

## *Chapter Three*

1. Morienus, *De compositione alchemiae*, in *Bibliotheca chemica curiosa*, 1:509–19, quoting from p. 509; this Latin edition is fairly corrupt—I have silently changed its *vestra* to *nostra* in accord with some manuscripts. For an English translation and an alternate Latin text (omitting the prologue), see Morienus, *A Testament of Alchemy*, ed. and trans. Lee Stavenhagen (Hanover, NH: Brandeis University Press, 1974); the translation is not always accurate. The authenticity of the work as a translation from Arabic rather than as an original Latin composition was denied by Julius Ruska, *Arabische Alchemisten I*, pp. 33–35, but partial Arabic versions have since been found: Ullmann, *Natur- und Geheimwissenschaften*, pp. 192–93, and al-Hassan, "The Arabic Original." The authenticity of Robert's prologue as a twelfth-century work has also been called